

# PCA Based Facial Expression Detection Techniques

**NAGOOR BABU SHAIK**  
PG Scholar, Department of ECE  
G.K.C.E, sullurpet, Andhrapradesh, INDIA.

**Dr. G. CHENCHU KRISHNAIAH**  
Professor & Dean, Department of ECE  
G.K.C.E, sullurpet, Andhrapradesh, INDIA.

**Abstract:** Facial expression is a prominent posture beneath the skin of the face. They are the way of communication in humans which convey many things non-verbally. During the past years face recognition has received significant attention as one of the most important applications of image understanding and analysis. Many algorithms have been implemented on different static and non-static conditions. Static conditions include static and uniform background, identical poses, similar illumination, neutral frontal face. Non static conditions include position, partial occlusion orientation; varying lightening conditions and facial hair which make recognition process a complex problem. All these factors influence face recognition process. The main stages for face recognition include face detection, feature representation and classifications. Researchers have described distinct approaches for face recognition. In this work we present a glimpse of face detection techniques, methods used, their performance & their limitations and proposed a new technique for Face Detection based on Viola and Jones algorithm and principal component analysis. At the end we have shown simulation results for the proposed technique and established that proposed technique is performing better than the existing one.

**Keywords**—Eigen face; Facial Expression Detection; Gabor Filter; Principal Component Analysis;

## I. INTRODUCTION

In recent decade, facial expression recognition has become a progressive areas of research. There are many applications and algorithms that use facial expressions to evaluate human nature, feelings, judgment, opinion. These expressions are produced as a result of distortions of facial features due to the contraction of facial muscles. Facial expression recognition is not an easy task because of circumstances like illumination, facial occlusions, face color, face shape etc..

Face detection systems have many problems pertaining to pose, light, facial expression and quality of picture. It can be solved by applying some sort of image preprocessing before they are applied for further analysis purpose.

The facial expression detection system is divided into four major steps:

1. Face detection
2. Normalization
3. Feature extraction
4. Classification

Face detection & normalization phase detects the face and lighting effects are reduced to some extent. The next step is feature extraction which extracts the features & irrelevant features are eliminated in feature selection process. Final step is classification where the facial expressions are classified in to four basic emotions shown in Fig. 1. Generally, there are two techniques in the facial expression recognition process the first technique is based on facial feature & the other considers the holistic view of the recognition problem.

## A. Feature based approach

In this approach the local features (like nose, eyes) of the face are found. Then these features are segmented & then they are used as the input data for structural classifier. The techniques like dynamic link architecture, pure geometry & hidden Markov model (HMM) are classified under this category.



**Fig.1. Examples of four basic emotions (neutral, happiness, sadness and surprise) uses includes tracking facial features, detection of activation of facial muscles (Facial Action Units).**

## B. Holistic approach

In this approach the statistical methods are used to extracts the statistical characterization from the entire training sample images. There are techniques like eigen faces, probabilistic eigen faces, fisher face, support vector machines(SVM), nearest feature lines (NFL) and independent-component analysis which use holistic approach for facial expression detection.

## C. Hybrid approach

Hybrid approach is a combination of above two mentioned approaches. The idea of this method comes from how human vision system perceives both local features and whole face. The methods like modular eigenface, hybrid local feature, shape

normalized, and component based methods are used in hybrid approach.

## II. LITERATURE REVIEW

In 1977, Ekman and Friesen developed a famous and flourishing facial action coding system. The Facial Action Coding System (FACS) identifies the facial muscles that cause changes in the facial expression thus enabling facial expression analysis. This system consists of 46 Action Units(AU) describing the facial behaviors. Line based caricature of the facial expression for the line edge map (LEM) descriptor, measuring the line segment Hausdorff distance (measures how far two subsets of a metric space are from each other) among the line caricature of the expressions and the LEM of test faces. They achieve an optimal value, viewing that the average detection rate of females was 7.8% higher than that of males. Lajevardi and Wu offered a tensor based representation of the static color images. They achieved 68.8% accuracy in recognizing the expression with different resolutions in color space. Neural network is proposed in that compresses the whole face region with 2-D discrete cosine transform. Ma and Khorasani comprehensive this image compression with the constructive one hidden layer neural network with the optimal block size to be 12 and the upper limit number of hidden units, therefore attaining the accuracy rate of almost 93.75%.

Researchers have likewise used the MPEG-4 standard to provide the facial action parameters (FAP) to interpret the facial aspects. Aleksic and Katsaggelos developed a facial expression detection system utilizing these facial action parameters basically describing the eyebrow and the outer lip features, and classifying up to 93.66% of the test expressions by calculating the maximum likelihoods generated by the mainstream hidden Markov model (MS-HMM). Huang and He presented a super resolution method to improve the face detection of low resolution images. They applied canonical correlation analysis (CCA) to obtain the coherent features of the high resolution (HR) and low resolution (LR) images, and employed radial basis functions (RBF) based nonlinear mapping favoring the nearest neighbor (NN) classifier for detection of single input low resolution picture. The detection rate of their method tested on the Facial Detection Technology (FERET) face database was 84.4%, 93.0% for UMIST database, and 95.0% of the Olivetti Research Laboratory (ORL) database. The approach of Eigenface method was given by Turk and Pentland. Murthy and Jadon enhanced this method to recognize the expression of the front view of the face, tested for the Cohn-Kanade (CK) Facial Expression database and Japanese female facial expression (JAFFE) database. Zhi, Flierl, Ruan, and Kleijn used the projected gradient

method and developed the graph-preserving sparse non-negative matrix factorization (GSNMF) for extraction of feature verified on different databases. They achieved an accuracy of 93.3% detection for eye occlusion, 94.0% for nose occlusion, 90.1% for mouth occlusion and 96.6% for impulsive facial expression.

Mase and Pentland projected the activity of the facial muscles using dense optical flow. In new approach was extended combined with the face model, using recursive estimation and achieved 98.0% accuracy. Keith Anderson and Peter W. McOwan used an enhanced ratio template algorithm to identify the frontal view of the face, and chose the multichannel gradient model for motion of the face. They analyzed detection system using support vector machine classifier (SVM) and noted 81.82% detection rate. In, the elastic graph matching (EGM) algorithm has been recommended and the analysis conducted for the feature extraction was a novel 2-class kernel discriminate analysis to get better the performance for the facial expression detection. The detection accuracy achieved 90.5% for Gabor-based elastic graph matching method, but for the normalized morphological based elastic graph matching method was 91.8%. Facial expression detection has been analyzed on visible light images, but new algorithm made a database for detection of expression of both visible and infrared images. Gabor wavelets were also useful for sensing as it shows the enticing attributes of specific spatial location and sparse object representation. Liu and Wechsler presented Gabor-Fisher based classification for face detection using the Enhanced Fisher linear discriminant Model (EFM) along with the augmented Gabor feature, tried on 200 fields. Zhang and Tjondronegoro presented patch-based Gabor feature extraction from the automatically cropped images, in the kind of patches matched the patches of the input image with the trained images by comparing the distance metrics and classification carried out by four different kernels support vector machine. The effects were seen for two databases, obtaining correct detection rate of 92.93% for JAFFE database and 94.8% for CK database. Two new methods were proposed in , first discovering the dynamic facial expressions directly and second facial action units based detection. The sorting was performed using SVM.

## III. TECHNIQUES USED FOR FACIAL EXPRESSION DETECTION

There are different face detection techniques that apply mostly to the frontal faces. The methods which are habituated for the face detection are Eigenfaces (Eigen features) , Neural Networks , Principal Component Analysis , Hidden Markov Model, Geometrical Feature Matching.

**A. Principal Component Analysis (PCA)** Principal Component Analysis (PCA), also known as the eigen face approach and is one of the popular methods for facial expression detection. Face can be easily reconstructed by only considering small amount of information that can be obtained by using Eigen faces.

**B. Hidden Markov model** HMM need a series of experimental 1D and 2D images; images should be transformed to either a chronological sequence of 1D or spatial.

**C. Geometrical feature matching** This techniques works on the calculation of a set of geometrical features from the picture of a face. It is based on computation of a group of photos from the face geometry. It probably identifies a face even in the improper resolution as low as 8\*6 pixels.

**D. Neural network.** Here all the subnets are trained for their own images. The subnets are trained on decision basis with different samples. The main advantage of the neural network in the face detection is the feasibility of training a system to capture the complex class of face patterns.

**E. Template Matching** This approach can exploit other face templates from different datasets in order to characterize a single face. The complexity arises only during the extraction of template.

#### IV. PREVIOUS METHOD

Facial expression is one of the most powerful, natural and immediate means for human beings to communicate their emotions and intentions. Facial expression carries crucial information about the mental, emotional and even physical states of the conversation. It is a desirable feature of the next generation human-computer interfaces. Computers that can recognize facial expressions and respond to the emotions of humans accordingly enable better human - machine communication development of information technology Recognition of facial expression in the input image needs two functions: locating a face in the image and recognizing its expression. We believe recognition of human facial expression by computer is a key to develop such technology. In recent years, much research has been done on machine recognition of human Facial expressions. Conventional methods extract features of facial organs, such as eyes and a mouth and recognize the expressions from changes in their shapes or their geometrical relationships by different facial expressions when we watch two photos of a human face, we can answer which photo shows the facial expression more strongly. Accordingly, as extending the step of facial expression recognition, we think it is important to develop a measurement method of the strength of facial expressions. One of the key remaining problems in face recognition is

to handle the variability in appearance due to changes in pose, expression, and lighting conditions. There has been some recent work in this direction. The increasing progress of communication technology and computer science has led us to expect the importance of facial expression in future human machine interface and advanced communication, such as multimedia and low-bandwidth transmission of facial data In human interaction, the articulation and perception of facial expressions form a communication channel, that is additional to voice and that carries crucial information about the mental, emotional and even physical states of the conversation. Face localization, feature extraction, and modeling are the major issues in automatic facial expression recognition.

#### V. PRE-PROCESSING TECHNIQUES

Image pre-processing techniques takes the form of signal conditioning (such as noise removal, variation of pixel position) together with segmentation, location and is used for detection and tracking of a face or its parts. Steps involved in pre- processing of an image are as briefed in this section.

##### A. Read Image

In this phase a method that can extract the shape of the eyes, nose, mouth and chin, is used and it helps to distinguish the face by distance and scale of those organs.



**Fig.2. Image to be read**

##### B. Detect Image

The main concern of face detection is to identify all image regions which contain a face regardless of its direction, background & lighting conditions. Such task is tricky since faces can have a vast assortment in terms of shape, color, size or texture. Image detection phase does this.



**Fig.3. Detected Image**

##### C. Identify Facial Feature Points

Feature points of an image like eyes, chin, eyebrows, lips, nose, etc. are identified and marked during this phase.

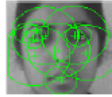


Fig.4. Image Facial Feature point detected

#### D. Color Space Transformation and Lighting Compensation

In this phase skin-color detection is used as an intermediate step of face detection.

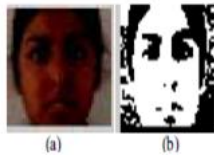


Fig.5(a). Normal Image. 5(b) Color Space Transformation of an Image

#### E. High Frequency Noisy Removing

Noise from the image is removed in this stage using noise removal algorithms



Fig.6. Noise Removal from the Image

#### F. Edge Detection and Size Reduction

Image edges are detected and marked in this stage. End points of features, chooses the dimensionality reducing linear projection that maximize the scatter of all projected samples.



Fig.7. Edge Detection and Size Reduction

### VI. RESULTS

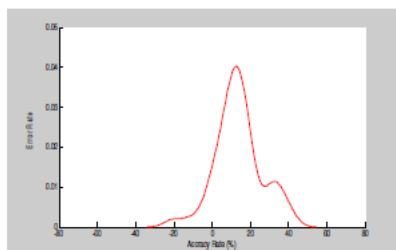


Fig.8. Existing Graph

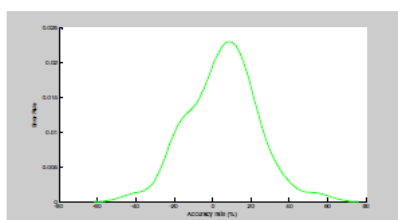


Fig.9. Proposed Graph

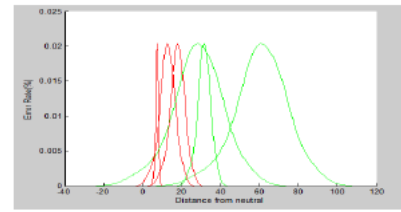


Fig.10. Comparative Results of Base versus Proposed

Fig.8 and Fig.9 shows the accuracy rate of Viola jones algorithm against the proposed work respectively. As compared to existing system the accuracy rate of 99.0744% the proposed systems accuracy goes up to 99.84% on multiple person images. The error rate of existing system is 0.04 whereas in proposed work it falls down to 0.023. Accuracy rate is calculated on the basis of distance from neutral and error ratio. Fig.10, shows the distances calculated from the neutral in existing system (red lines) and the proposed (green lines).

### VII. CONCLUSION

In this paper we discussed Face Detection Technique based on Viola and Jones algorithm and principal component analysis with the help of this technique, we can recognize an accurate and high speed emotion detection system.













Test Image	Distance from Neutral	Expressions	Best Match
	1418	neutral	
	6807	sad	
	11581	happy	
	15993	sad	
	7065	happy	
	1418	neutral	

Table I. Expression Detection Using Viola and Jones algorithm













Test Image	Distance from Neutral	Expressions	Best Match
	9744	neutral	
	3516	happy	
	6039	sad	
	5096	happy	
	8273	neutral	
	13518	sad	

Table II. Expression Detection Using Proposed System

The techniques used in this work detect human facial expressions and recognize them on the basis of accuracy and computational time. Some of them contain drawbacks in term of detection rate, accuracy or timings. The most optimum detection rate can be obtained through combination of given techniques, extract the features from the images as per ones need and final comparison can be done to find out the results. The success of implementation



depends on pre-processing stage on the images because of illumination and feature extraction.

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### AUTHOR's PROFILE



**Nagoor Babu. Shaik** received the B.Tech Degree from Priyadarshini college of Engineering, Sullurpet in 2011, Currently pursuing his post graduation (M.Tech.) from Gokula Krishna College of Engineering, Sullurpet, SPSR Nellore (Dist), A.P, India.

**Dr. G. Chenchu Krishnaiah** Obtained his B.Tech Degree in ECE from KSRM College of Engineering, Kadapa, A.P, India and Master of Engineering (ME) Degree in Applied



Electronics(AE) from Sathyabhama University, Chennai, India. He earned his Ph.D Degree (Effective Image Compression using Evolved Wavelets ) in ECE Department from JNT University, Anantapur, A.P, India. He has 16 years of experience in teaching field. Presently he is working as a Professor & Dean at Gokula Krishna College of Engineering, Sullurpet, SPSR Nellore (Dist), A.P, India. His area of research interest includes wavelet Transforms, Digital Image Processing, compression and Denoising algorithms Digital Signal Processing, Embedded Systems,VLSI Design and VHDL Coding. He is a life member of ISTE(India).